
ENVIRONMENTAL Fact Sheet



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Manganese: Health Information Summary

Manganese is a common element in the earth's crust, water, and particulate matter in the atmosphere. This element is used in manufacturing steel, dry cell batteries, electrical coils, ceramics, matches, glass, fertilizers, fungicides, and welding rods. Manganese may be used as an additive to animal food and in antiseptic solutions. It is also a constituent of a gasoline additive (MMT), primarily for fuel sold in Canada. MMT in US fuel supplies is currently at a very low 0.02 percent.

Manganese is an essential nutrient, present in all living organisms. While manganese is present in air and in most water supplies, the major portion of an individual's intake is derived from food. Drinking water usually comprises only a very small proportion of the total exposure.

The principal sources of manganese in the atmosphere are natural processes including continental dust, volcanic gas and dust, and forest fires. Other sources are industrial emissions and combustion of fossil fuels. In water, manganese may undergo chemical reactions or may persist for up to several hundred years. A survey of public water supplies found about 95 percent contained manganese at a concentration of less than 100 parts per billion (ppb).

Health Effects

Manganese Nutrition

Because manganese is an essential nutrient, a certain amount must be ingested on a regular basis to maintain health. Although the precise requirement has not been determined, 2.5 to 5.0 milligrams per day (mg/day) has been estimated to constitute an adequate and safe intake. Typical daily intakes in the United States range between one and 6.4 mg/day. Those who take supplements containing manganese may ingest an amount equal to the average intake from food. Foods that are high in manganese include nuts, beans, tea, and whole grains, while there is little manganese in meat, dairy, and refined grains. Therefore, individuals eating plant-based diets are likely to have the highest intakes of manganese. However, because plants also contain substances such as fiber that interfere with the absorption of manganese, the body is not able to utilize all the extra manganese provided by vegetarian diets.

Absorption

Limited data indicate that gastrointestinal absorption of manganese is low, averaging approximately 3 percent. The body has mechanisms that can usually control the total amount of manganese by increasing its elimination if excess levels are consumed. Because manganese and

iron compete for gastrointestinal absorption, manganese uptake from the gut is likely to be increased in iron-deficient persons. Inhaled manganese may be absorbed in the lungs if the particles are small enough. Absorption through the skin is expected to be very low at less than 1 percent.

Short-Term (acute) Toxicity

Studies in animals and humans indicate that inorganic manganese has a very low acute toxicity by any route of exposure. However, acute inhalation exposure to high levels of manganese dust can cause an inflammatory response in the lung.

In a human study, women took daily manganese supplements of 15 mg for 90 days. No toxic effects to the blood were seen.

Long-Term (chronic) Toxicity

Conclusive evidence that overexposure to manganese can result in adverse health effects has been observed in miners and steel workers exposed by inhalation to manganese dusts. The range of effects seen is called "manganism" or referred to as "manganese-induced Parkinsonism," because some of the symptoms are similar to those seen in cases of Parkinson's disease. Symptoms include muscle tremor, reduced motor skills, difficulty and slowing of walking, slurred speech, and, sometimes, psychiatric disturbances.

There are a few reports in the literature examining the effects of excess oral exposure of humans to manganese. One report describes symptoms of lethargy, increased muscle tone, spasm, tremors and mental abnormalities in persons drinking water contaminated by manganese from dry cell batteries buried nearby. The actual length of time that people were drinking the water was not clear. The exposure time spanned a period of two to three weeks for some individuals and potentially much longer for other members who developed symptoms. When the water was tested, it contained manganese at a concentration of 14.3 milligrams per liter (mg/l; equivalent to parts per million or ppm). Those who studied this event believe it likely that other factors, possibly chemicals in the water beside manganese, contributed to the health effects.

A study was conducted to evaluate populations in three areas of Greece, each containing different levels of manganese in their drinking water. Neurological examinations were conducted on individuals within each population. Significantly higher neurological scores indicating muscular disorders including weakness/fatigue, disturbance in walking, and tremors were found in the area with the highest manganese levels (1.6 - 2.3 ppm in water) compared with the area having the lowest. However, differences in each population that may not have been controlled for, such as age, occupational exposures, or general health status, make it difficult to be certain that manganese was the only causative factor.

Another study conducted in Germany comparing nervous system status between those exposed for many years to high (0.30 - 2.16 ppm) and low (less than 0.05 ppm) manganese levels in drinking water detected no difference between the two groups in nervous system functioning.

Animal data regarding toxic effects of oral manganese exposure are limited. A study conducted in monkeys receiving elevated oral doses for 18 months reported weakness and muscular rigidity. One animal study in which rats were exposed to 2,000 ppm of manganese in the diet failed to produce symptoms of central nervous system abnormalities.

Specific populations that may be more sensitive to manganese include infants, those with liver disease, and the elderly. Evidence indicates that infants absorb more of the metal than adults and those with liver disease are more susceptible because manganese is removed from the blood by the liver for excretion. It is not known for certain why older populations appear to more susceptible but possible explanations include normal declines in nervous system function with age or the accumulated effects of other environmental toxins make this group more vulnerable to manganese's effects.

Carcinogenic (cancer-causing) Effects

Information regarding the carcinogenicity (ability to cause cancer) of manganese in humans or animals is not available. Therefore, the U.S. Environmental Protection Agency (EPA) has classified manganese in Group D, inadequate evidence to determine its carcinogenicity under the old EPA cancer categorization scheme. Under the new EPA cancer guidelines, it would be appropriate to classify manganese into the "inadequate information to assess carcinogenic potential" category.

Reproductive/Developmental Effects

There are a few reports associating intake of manganese with reproductive effects in humans. Impotency in males has been reported in association with occupational inhalation exposure to manganese. Animal studies found an association with very high levels in food and an increase in birth defects. Another study found decreased levels of the male hormone testosterone without any decrease in reproduction in male rats fed diets containing 1,050 ppm of manganese.

Health Standards and Criteria

EPA-Region I has derived a health-based clean up level for manganese in groundwater at 0.84 ppm. DES has adopted this value as a guideline for manganese in drinking water. The guideline is based on subtracting the average manganese content in a typical US diet of 5 mg/day from the upper safe manganese intake level of 10 mg/day. The potential for greater absorption of manganese consumed in water as opposed to food is also taken into account by an additional three-fold reduction in the drinking water guideline.

A report reviewing the available information on manganese was published in 2001 by a committee drawn from the Food and Nutrition Board of the Institute of Medicine (IOM). The values they selected of 6 mg/day as an average dietary intake of manganese and 11 mg/day as an upper safe intake level are very close to those reported by the EPA. The IOM report also noted the potential for greater absorption of manganese in water compared to food.

There is a federal and state standard for an acceptable level of manganese in drinking water based on the aesthetic qualities of taste, smell, and staining of bath fixtures, rather than on the potential to cause adverse health effects. This Secondary Maximum Contaminant Level (SMCL) is 0.05 ppm. Manganese staining of fixtures usually produces a brownish-black color, compared to blue-green for copper and reddish-brown for iron.

Suggested Reading and References

Casarett and Doull's Toxicology: The Basic Science of Poisons, Sixth Edition. Klaassen, C.D., ed. McGraw-Hill Publishing Co., Inc., New York, 2001.

Toxicological information on manganese. Integrated Risk Information System (IRIS). U.S. EPA, Office of Health and Environmental Assessment.

Dietary Reference Intakes for Vitamin A, Vitamin K, Arsenic, Boron, Chromium, Copper, Iodine, Iron, Manganese, Molybdenum, Nickel, Silicon, Vanadium, Zinc. Food and Nutrition Board. Institute of Medicine. National Academy Press. Washington, DC, 2001.

Toxicological Profile for Manganese (Update). Agency for Toxic Substances and Disease Registry (ATSDR). Atlanta, GA. September, 2000.

"Risk Updates." U.S. Environmental Protection Agency-Region I, New England. November, 1996.